CHAPTER 13

POWER TRAINS

CHAPTER LEARNING OBJECTIVES

Upon completion of this chapter, you should be able to do the following:

● *Explain the mechanism of a power train.*

In chapter 12 we saw how a combination of simple machines and basic mechanisms was used in constructing the internal combustion engine. In this chapter we will learn how the power developed by the engine is transmitted to perform the work required of it. We will demonstrate the power train system used in automobiles and most trucks in our discussion. As we study the application of power trains, again look for the simple machines that make up each of the machines or mechanisms.

AUTOMOTIVE POWER TRAINS

In a vehicle, the mechanism that transmits the power of the engine to the wheels or tracks and accessory equipment is called the power train. In a simple situation, a set of gears or a chain and sprocket could perform this task, but automotive and construction

vehicles are not usually designed for such simple operating conditions. They are designed to have great pulling power, to move at high speeds, to travel in reverse as well as forward, and to operate on rough terrain as well as smooth roads. To meet these widely varying demands, vehicles require several additional accessory units.

The power trains of automobiles and light trucks driven by the two rear wheels consist of a clutch, a transmission, a propeller shaft, a differential, and driving axles (fig. 13-1).

Four- and six-wheel drive trucks have transfer cases with additional drive shafts and live axles. Tractors, shovels, cranes, and other heavy-duty vehicles that move on tracks also have similar power trains. In addition to assemblies that drive sprockets to move the tracks, these vehicles also have auxiliary transmissions
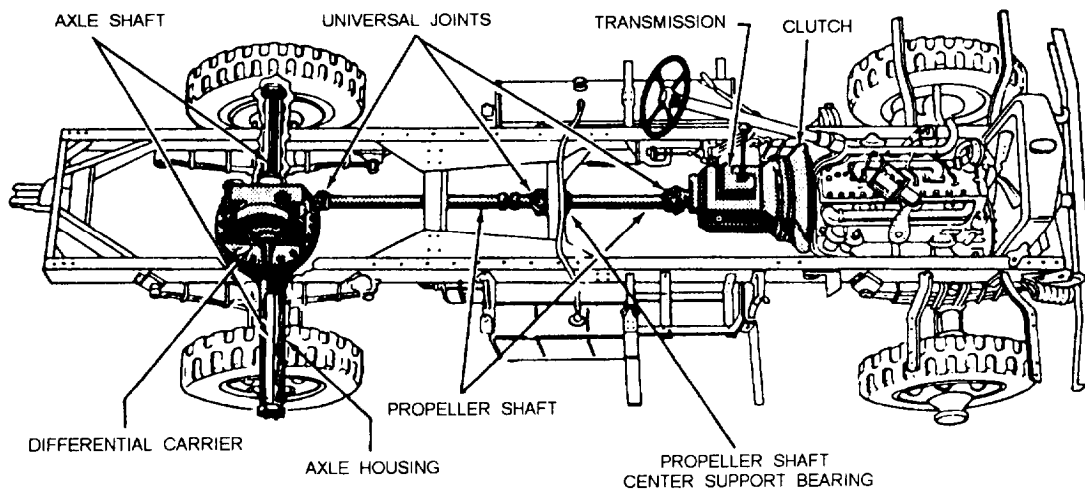

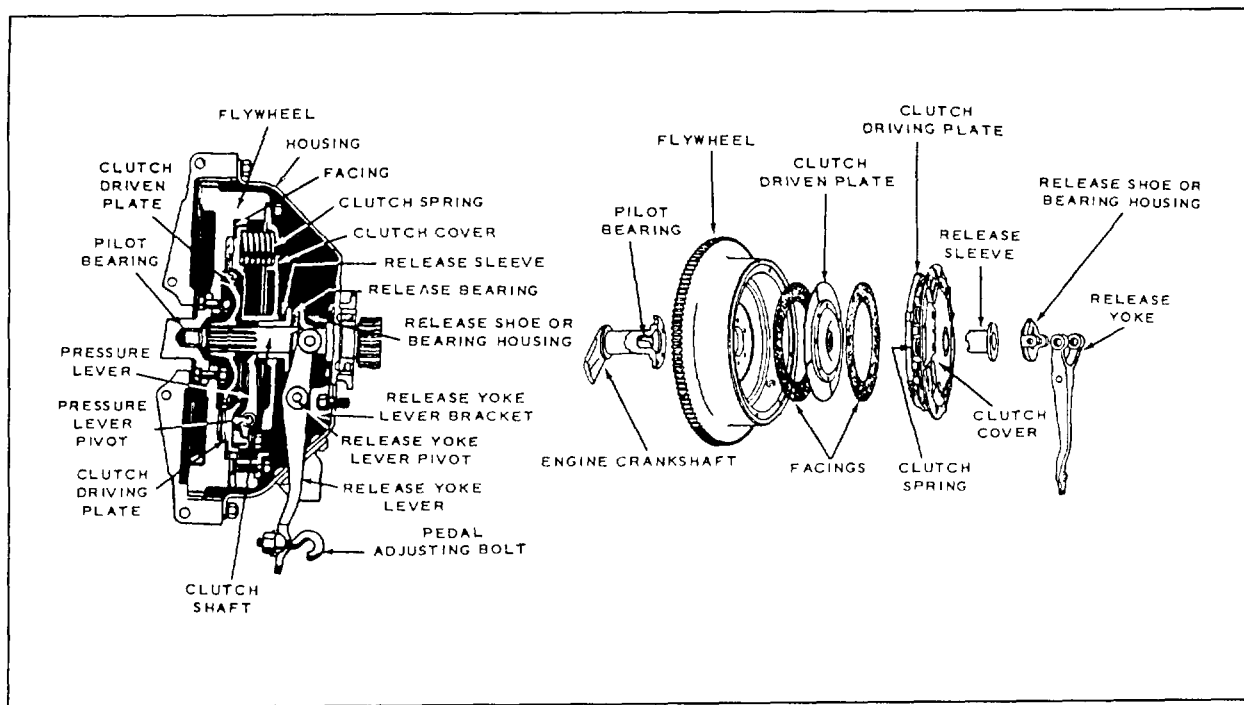Figure 13-1.-Type of power transmission.

Figure 13-2.-Exploded and cross-sectional views of a plate clutch.

or power takeoff units. These units may be used to operate accessory attachments. The propeller shafts and clutch assemblies of these power trains are very much like those used to drive the wheels.

THE CLUTCH

The clutch is placed in the power train of motorized equipment for two purposes:

First, it provides a means of disconnecting the power of the engine from the driving wheels and accessory equipment. When you disengage the clutch, the engine can run without driving the vehicle or operating the accessories.

Second, when you start the vehicle, the clutch allows the engine to take up the load of driving the vehicle or accessories gradually and without shock.

Clutches are located in the power train between the source of power and the operating unit. Usually, they are placed between the engine and the transmission assembly, as shown in figure 13-1.

Clutches generally transmit power from the clutch-driving member to the driven member by friction. Strong springs within the plate clutch (fig. 13-2) gradually bring the driving member (plate), secured to the engine flywheel, in contact with the driven member

(disc). The driver of the automobile controls the pressure of the springs through use of the clutch. If the driver only applies light pressure, little friction takes place between the two members, which permits the clutch to slip. As the driver increases pressure, friction also increases and less slippage occurs. When the driver's foot releases pressure from the clutch pedal and applies full spring pressure, the driving plate and driven disc move at the same speed. All slipping then stops because of the direct connection between the driving and driven shafts.

In most clutches, a direct mechanical linkage exists between the clutch pedal and the clutch release yoke lever. Many late model vehicles and some larger units that require greater pressure to release the spring use a hydraulic clutch release system. A master cylinder (fig. 13-3), similar to the brake master cylinder, attaches to the clutch pedal. A cylinder, similar to a single-acting brake wheel cylinder, connects to the master cylinder by flexible pressure hose or metal tubing (fig. 13-3). The slave cylinder connects to the clutch release yoke lever. Movement of the clutch pedal actuates the clutch master cylinder. Hydraulic pressure transfers this movement to the slave cylinder, which, in turn, actuates the clutch release yoke lever.

We use various types of clutches. Most passenger cars and light trucks use the previously mentioned plate
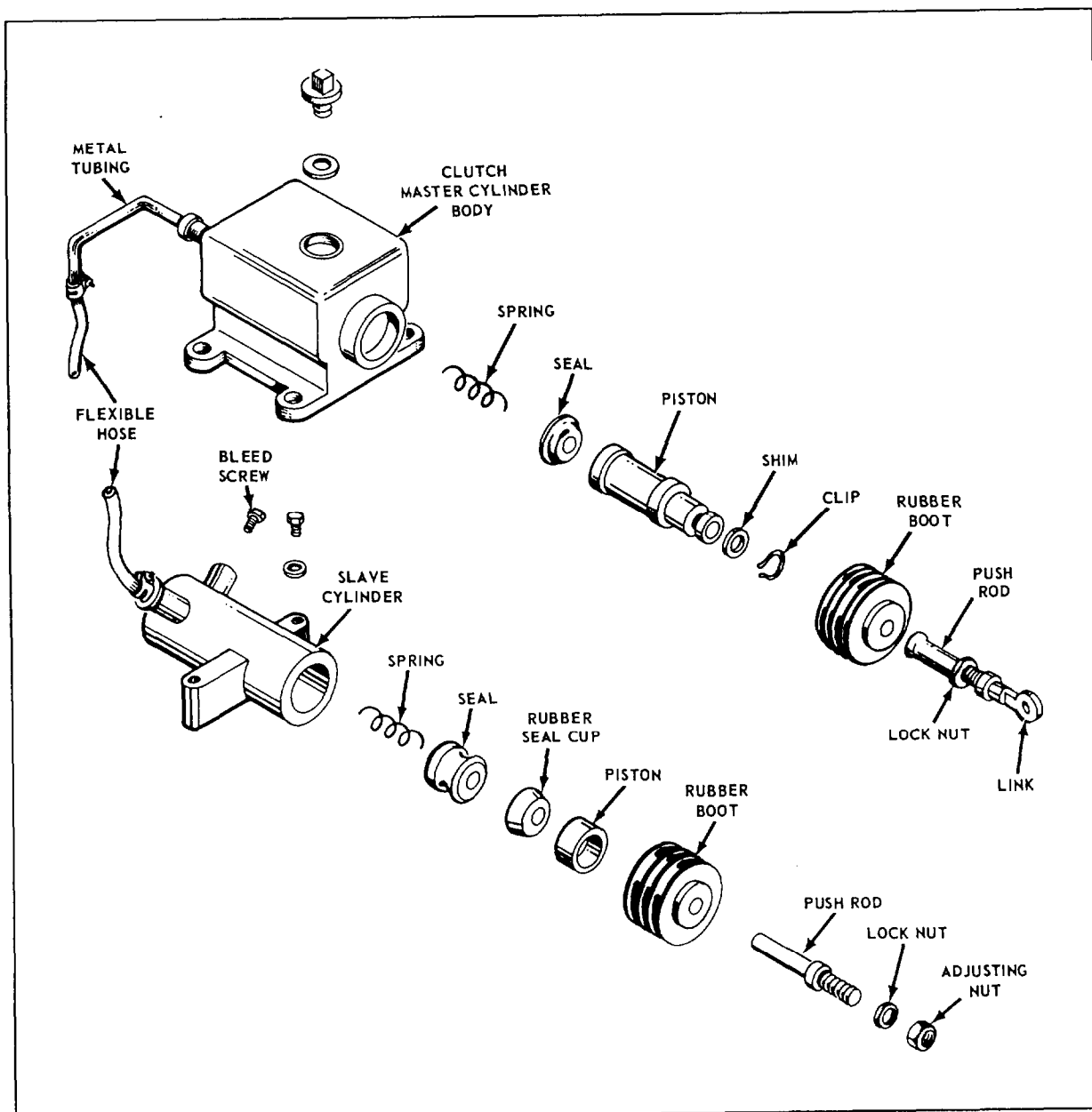
Figure 13-3.-Master cylinder, slave cylinder, and connections for standard hydraulic clutch.

clutch. The plate clutch is a simple clutch with three plates, one of which is clamped between the other two. Figure 13-2 shows exploded and cross-sectional views of a plate clutch.
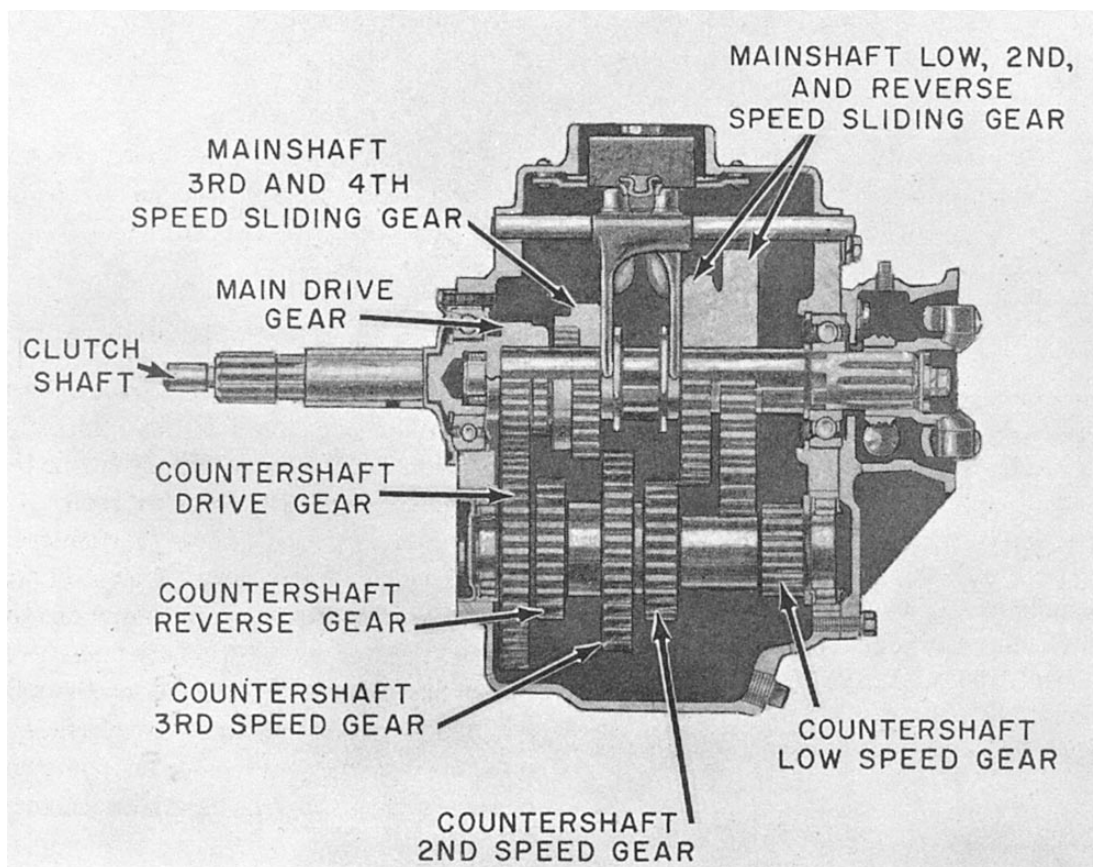
SINGLE-DISK CLUTCH

The driving members of the single-disk clutch consist of the flywheel and the driving (pressure) plate. The driven member consists of a single disk, splined to the clutch shaft and faced on both sides with friction material. When the clutch is fully engaged, the driven disc is firmly clamped between the flywheel and the driving plate by the pressure of the clutch springs. That results in a direct, nonslipping connection between the driving and driven members of the clutch. In this position, the driven disc rotates the clutch shaft to which it is splined. The clutch shaft is connected to the driving wheels through the transmission, propeller shaft, final drive, differential, and live axles.
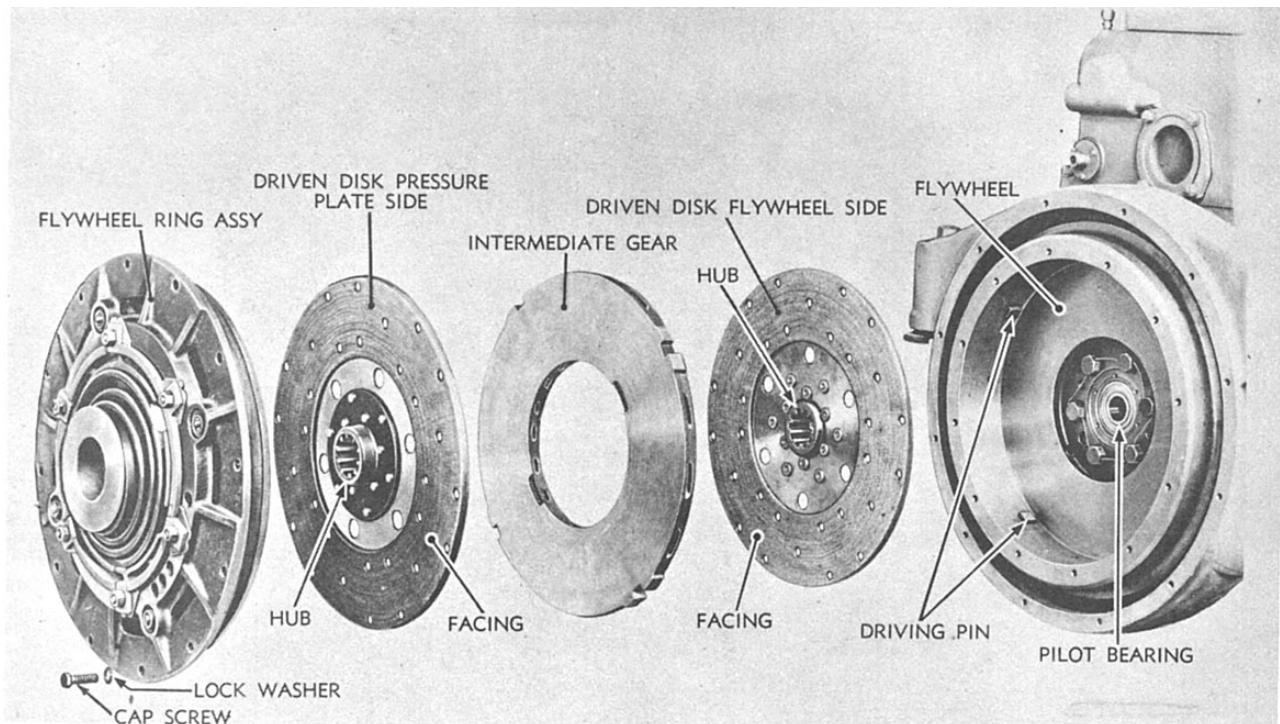
Figure 13-4.-Double-disk clutch-exploded view.

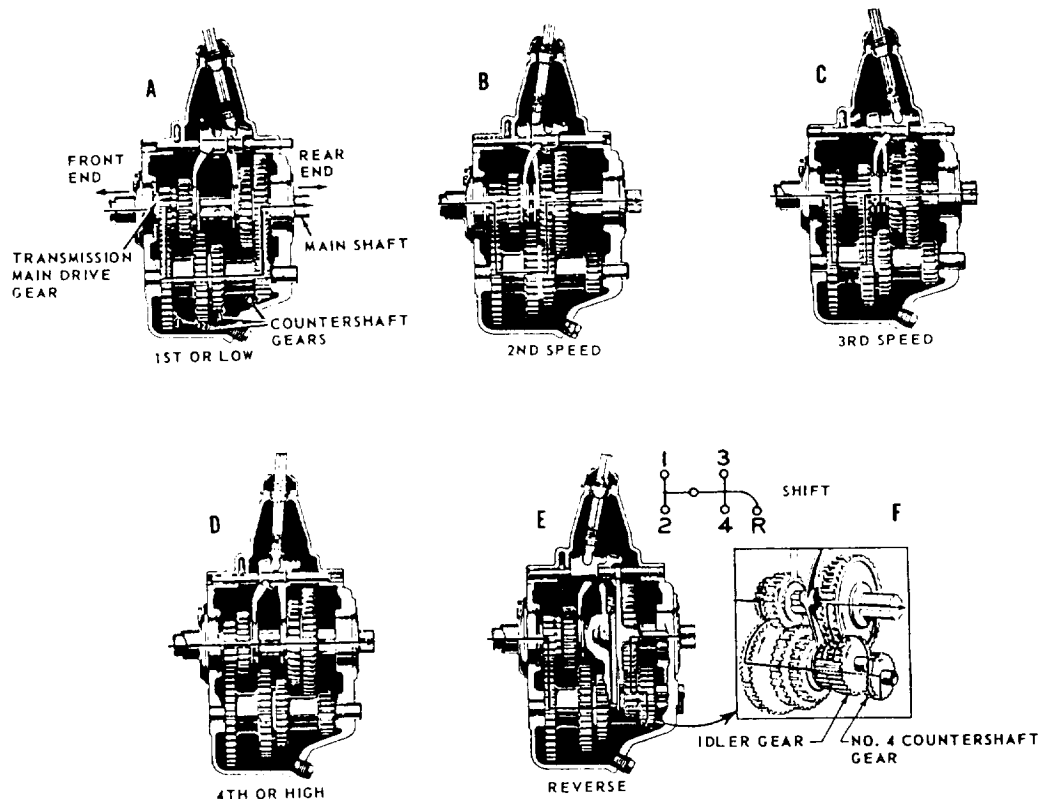**Figure 13-5.-Four-speed truck transmission.**

Figure 13-6.-Power flow through a four-speed transmission.

The double-disk clutch (fig. 13-4) is basically the same as the single-plate disk clutch except that another driven disk and intermediate driving plate are added.

MULTIPLE-DISK CLUTCH

A multiple-disk clutch is one having more than three plates or disks. Some have as many as 11 driving plates and 10 driven disks. Because the multiple-disk clutch has a greater frictional area than a plate clutch, it is suitable as a steering clutch on crawler types of tractors. The multiple-disk clutch is sometimes used on heavy trucks. Its operation is very much like that of the plate clutch and has the same release mechanism. The facings, however, are usually attached to the driving plates rather than to the driven disks. That reduces the weight of the driven disks and keeps them from spinning after the clutch is released.

You may run into other types of friction clutches such as the lubricated plate clutch and the cone clutch. These types are seldom used on automatic equipment. However, fluid drives are largely replacing the friction clutches in automobiles, light trucks, and some tractors.

For information on fluid drives (automatic transmissions), refer to *Construction Mechanic 3 & 2, NAVPERS 10644G-1*, chapter 11.

TRANSMISSION

The transmission is part of the power train. It consists of a metal case filled with gears (fig. 13-5). It is usually located in the rear of the engine between the clutch housing and the propeller shaft, as shown in figure 13-1. The transmission transfers engine power from the clutch shaft to the propeller shaft. It allows the driver or operator to control the power and speed of the vehicle. The transmission shown in figure 13-5 and 13-6 is a sliding gear transmission. Many late model trucks have either a constant mesh or synchromesh transmission (explained later). However, both transmissions have the same principles of operation and the same gear ratios.

A review of chapter 6 of this book will help you to understand the transmissions and power transfer mechanisms described in this chapter.

FOUR-SPEED TRUCK TRANSMISSION

The gear shift lever positions shown in the small inset in figure 13-6 are typical of most four-speed truck transmissions. The gear shifting lever, shown in A, B, C, D, and E of the figure, moves the position of the two shifting forks that slide on separate shafts secured in the transmission case cover. Follow the separate diagrams to learn what takes place in shifting from one speed to another. For example, as you move the top of the gear shift toward the forward left position, the lower arm of the lever moves in the opposite direction to shift the gears. The fulcrum of this lever is in the transmission cover.

Shifting transmission gears requires the use of the clutch to disengage the engine. Improper use of the clutch will cause the gears to clash and may damage them by breaking the gear teeth. A broken tooth or piece of metal can wedge itself between two moving gears and ruin the entire transmission assembly.

When you shift from neutral to first, or low, speed (fig. 13-6, A), the smallest countershaft gear engages with the large sliding gear. Low gear moves the truck at its lowest speed and maximum power. The arrows show the flow of power from the clutch shaft to the propeller shaft.

The second-speed position is obtained by moving the gear shift lever straight back from the low-speed position. You will, of course, use the clutch when shifting. In figure 13-6, B, you will see that the next to the smallest countershaft gear is in mesh with the second largest sliding gear. The largest sliding gear (shift gear) has been disengaged, The flow of power has been changed as shown by the arrow. The power transmitted to the wheels in second gear (speed) is less, but the truck will move at a greater speed than it will in low gear if the engine speed is kept the same.

In shifting from the second-speed to the third-speed position, you move the gear shift lever through the neutral position. You must do that in all selective gear transmissions. From the neutral position the driver can select the speed position required to get the power needed. In figure 13-6, C, notice that the gear shift lever is in contact with the other shifting fork and that the forward sliding gear meshes with the second countershaft gear. The power flow through the transmission has again been changed, as indicated by the arrow, and the truck will move at an intermediate speed between second and high.

You shift into the fourth, or high-speed, position by moving the top of the shift lever back and to the right from the neutral position. In the high-speed position, the forward shift or sliding gear is engaged with the constant speed gear as shown in figure 13-6, D. The clutch shaft and the transmission shaft are now locked together, and the power flow is in a straight line. In high, the truck propeller shaft revolves at the same speed as the engine crankshaft, or at a 1 to 1 ratio.

You shift to reverse by moving the top of the gear shift lever to the far right and then to the rear. Most trucks have a trigger arrangement at the gear shift ball to unlock the lever so that it can be moved from neutral to the far right. The lock prevents unintentional shifts into reverse. Never try to shift into reverse until the forward motion of the vehicle has been completely stopped.

In figure 13-6, F, you can see how the idler gear fits into the transmission gear train. In figure 13-6, E, you can see what happens when you shift into reverse. An additional shifting fork is contacted by the shift lever in the far right position. When you shift to reverse, this fork moves the idling gear into mesh with the small countershaft gear and the large sliding gear at the same time. The small arrows in the inset show how the engine power flows through the transmission to move the propeller shaft and the wheels in a reverse direction.

The different combination of gears in the transmission case makes it possible to change the vehicle speed while the engine speed remains the same. It is all a matter of gear ratios. That is, having large gears drive small gears, and having small gears drive large gears. If a gear with 100 teeth drives a gear with 25 teeth, the small gear will travel four times as fast as the large one. You have stepped up the speed. Now, let the small gear drive the large gear, and the large gear will make one revolution for every four of the small gear. You have reduced speed, and the ratio of gear reduction is 4 to 1.

In the truck transmission just described, the gear reduction in low gear is 7 to 1 from the engine to the propeller shaft. In high gear the ratio is 1 to 1, and the propeller shaft turns at the same speed as the engine. This principle holds true for most transmissions. The second- and third-speed positions provide intermediate gear reductions between low and high. The gear ratio in second speed is 3.48 to 1, and in third is 1.71 to 1. The gear reduction or gear ratio in reverse is about the same as it is in low gear, and the propeller shaft makes one revolution for every seven revolutions of the engine.
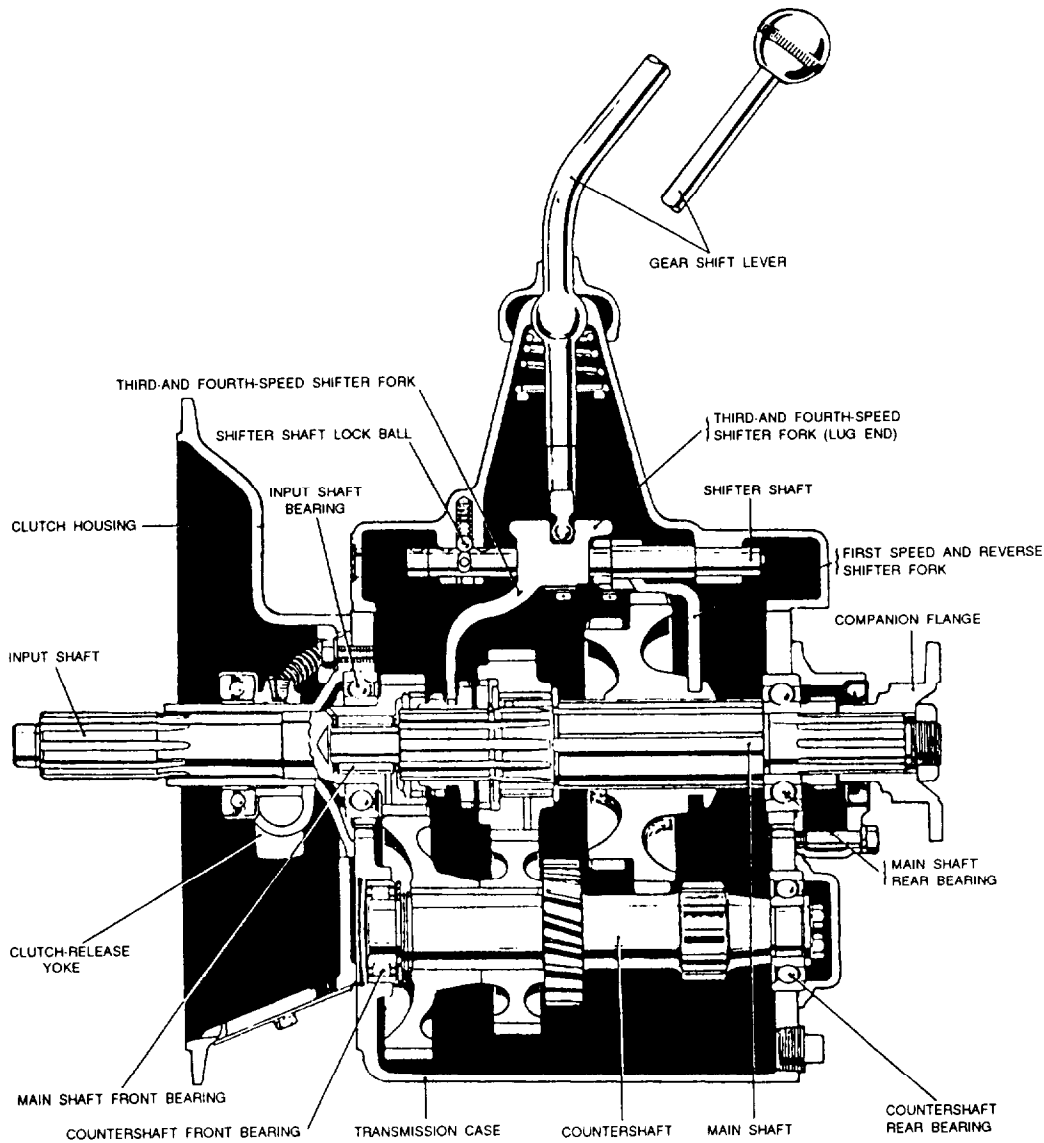
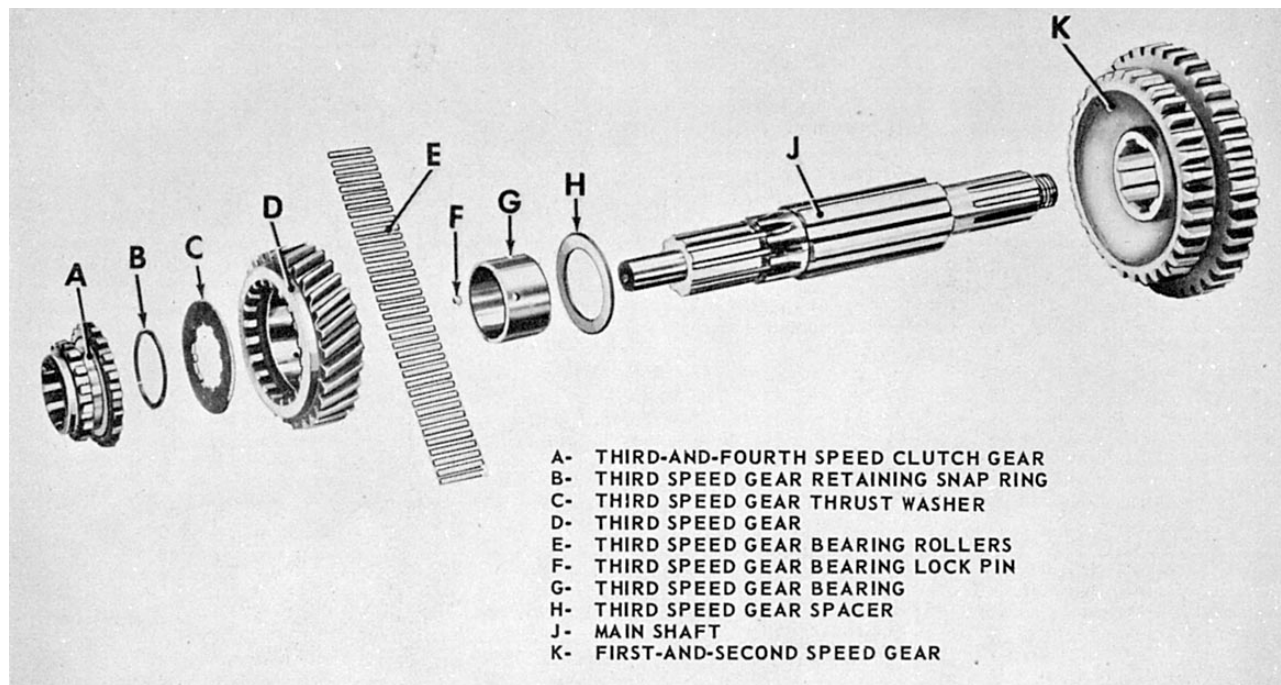Figure 13-7.-Constant-mesh transmission assembly—sectional view.

All transmissions do not have four speeds forward, and all do not have the same gear reductions at the various speeds. Passenger cars, for example, usually have only three forward speeds and one reverse speed. Their gear ratios are about 3 to 1 in both low and reverse gear combinations. You must remember, the gear reduction in the transmission is only between the engine and the propeller shaft. Another reduction gear ratio is provided in the rear axle assembly. If you have a common rear axle ratio of about 4 to 1, the gear reduction from the engine of a passenger car to the rear wheels in low gear would be approximately 12 to 1. In high gear the ratio would be 4 to 1 since the transmission would have no reduction of speed.

CONSTANT MESH TRANSMISSION

To eliminate the noise developed in the old spur-tooth type of gears used in the sliding gear transmission, the automotive manufacturers developed the constant-mesh transmission that contains helical gears.

In this type of transmission, certain countershaft gears are constantly in mesh with the main shaft gears. The main shaft meshing gears are arranged so that they cannot move endwise. They are supported by roller bearings that allow them to rotate independently of the main shaft (figs. 13-7 and 13-8).

In operation, when you move the shift lever to third, the third and fourth shifter fork moves the clutch gear

Figure 13-8.—Dissembled main shaft assembly.

A- THIRD-AND-FOURTH SPEED CLUTCH GEAR
B- THIRD SPEED GEAR RETAINING SNAP RING
C- THIRD SPEED GEAR THRUST WASHER
D- THIRD SPEED GEAR
E- THIRD SPEED GEAR BEARING ROLLERS
F- THIRD SPEED GEAR BEARING LOCK PIN
G- THIRD SPEED GEAR BEARING
H- THIRD SPEED GEAR SPACER
J- MAIN SHAFT
K- FIRST-AND-SECOND SPEED GEAR

(fig. 13-8, A) toward the third-speed gear (fig. 13-8, D). This action engages the external teeth of the clutch gear with the internal teeth of the third-speed gear. Since the third-speed gear is rotating with the rotating counter-shaft gear, the clutch gear also must rotate. The clutch gear is splined to the main shaft, and therefore, the main shaft rotates with the clutch gear. This principle is carried out when the shift lever moves from one speed to the next.

Constant-mesh gears are seldom used for all speeds. Common practice is to use such gears for the higher gears, with sliding gears for first and reverse speeds, or for reverse only. When the shift is made to first or reverse, the first and reverse sliding gear is moved to the left on the main shaft. The inner teeth of the sliding gear mesh with the main shaft first gear.
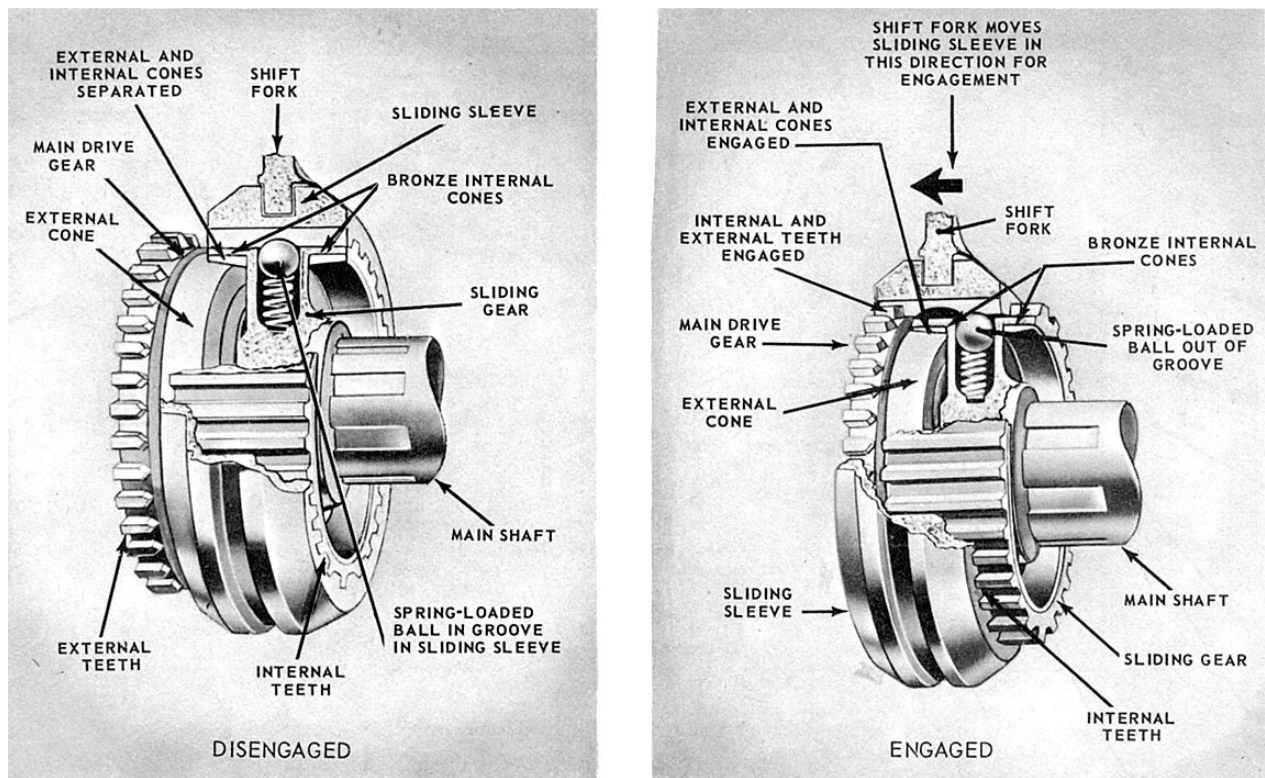
SYNCHROMESH TRANSMISSION

The synchromesh transmission is a type of constant-mesh transmission. It synchronizes the speeds of mating parts before they engage to allow the selection of gears without their clashing. It employs a combination metal-to-metal friction cone clutch and a dog or gear positive clutch. These clutches allow the main drive gear and second-speed main shaft gear to engage with the transmission main shaft. The friction cone clutch engages first, bringing the driving and driven members to the same speed, after which the dog clutch engages easily without clashing. This process is accomplished in one continuous operation when the driver declutches and

moves the control lever in the usual manner. The construction of synchromesh transmissions varies somewhat with different manufacturers, but the principle is the same in all.

The construction of a popular synchromesh clutch is shown in figure 13-9. The driving member consists of a sliding gear splined to the transmission main shaft with bronze internal cones on each side. It is surrounded by a sliding sleeve having internal teeth that are meshed with the external teeth of the sliding gear. The sliding sleeve has grooves around the outside to receive the shift fork. Six spring-loaded balls in radially drilled holes in the gear fit into an internal groove in the sliding sleeve. That prevents the sliding sleeve from moving endwise relative to the gear until the latter has reached the end of its travel. The driven members are the main drive gear and second-speed main shaft gear. Each has external cones and external teeth machined on its sides to engage the internal cones of the sliding gear and the internal teeth of the sliding sleeve.

The synchromesh clutch operates as follows: when the driver moves the transmission control lever to the third-speed, or direct-drive, position the shift fork moves the sliding gear and sliding sleeve forward as a unit until the internal cone on the sliding gear engages the external cone on the main drive gear. This action brings the two gears to the same speed and stops endwise travel of the sliding gear. The sliding sleeve slides over the balls and silently engages the external teeth on the main drive gear. This action locks the main drive gear and transmission main shaft together as shown in

Figure 13-9.-Synchromesh clutch-disengaged and engaged.
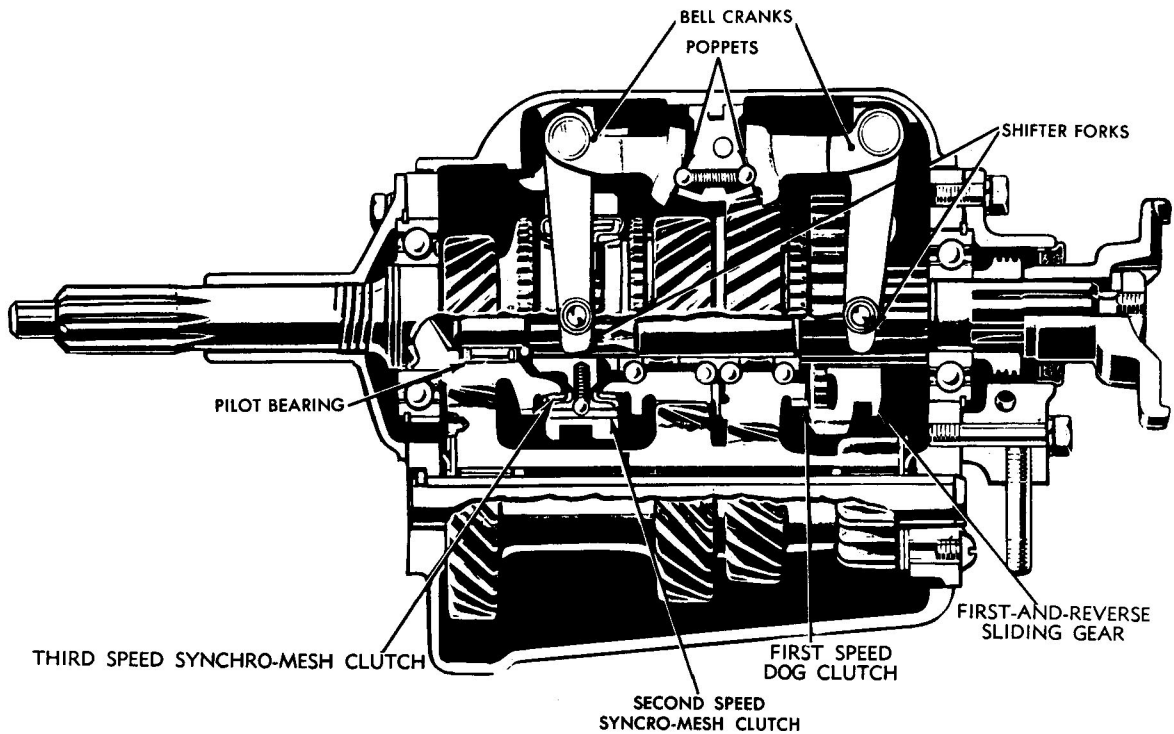
Figure 13-10.-Synchromesh transmission arranged for steering column control.

figure 13-9. When the transmission control lever is shifted to the second-speed position, the sliding gear and sleeve move rearward. The same action takes place, locking the transmission main shaft to the second-speed main shaft gear. The snchromesh clutch is not applied to first speed or to reverse. First speed is engaged by an ordinary dog clutch when constant mesh is employed by a sliding gear. Figure 13-10 shows a cross section of a
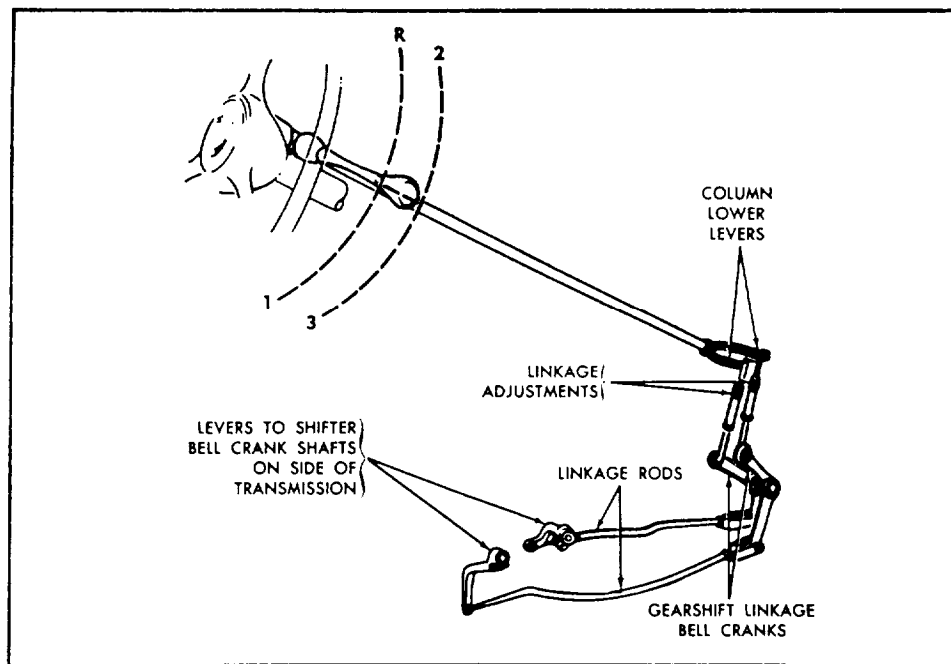
Figure 13-11.-Steering colunn transmission control lever and linkage.

synchromesh transmission that uses constant-mesh helical gears for the three forward speeds and a sliding spur gear for reverse.

Some transmissions are controlled by a steering column control lever (fig. 13-11). The positions for the various speeds are the same as those for the vertical control lever except that the lever is horizontal. The shifter fork is pivoted on bell cranks that are turned by a steering column control lever through the linkage shown. The poppets shown in figure 13-10 engage notches at the inner end of each bell crank. Other types of synchromesh transmissions controlled by steering column levers have shifter shafts and forks moved by a linkage similar to those used with a vertical control lever.

AUXILIARY TRANSMISSION

The auxiliary transmission allows a rather small truck engine to move heavy loads by increasing the engine-to-axle gear ratios. The auxiliary transmission provides a link in the power trains of construction vehicles. This link diverts engine power to drive four and six wheels and to operate accessory equipment through transfer cases and power takeoff units. (See fig. 13-12).

Trucks require a greater engine-to-axle gear ratio than passenger cars, particularly when manufacturers put the same engine in both types of equipment. In a

truck, the auxiliary transmission doubles the mechanical advantage. It connects to the rear of the main transmission by a short propeller shaft and universal joint. Its weight is supported on a frame crossmember as shown in figure 13-12. The illustration also shows how the shifting lever would extend into the driver's compartment near the lever operating the main transmission.

In appearance and in operation, auxiliary transmissions are similar to main transmissions, except that some may have two and some three speeds (low, direct, and overdrive).
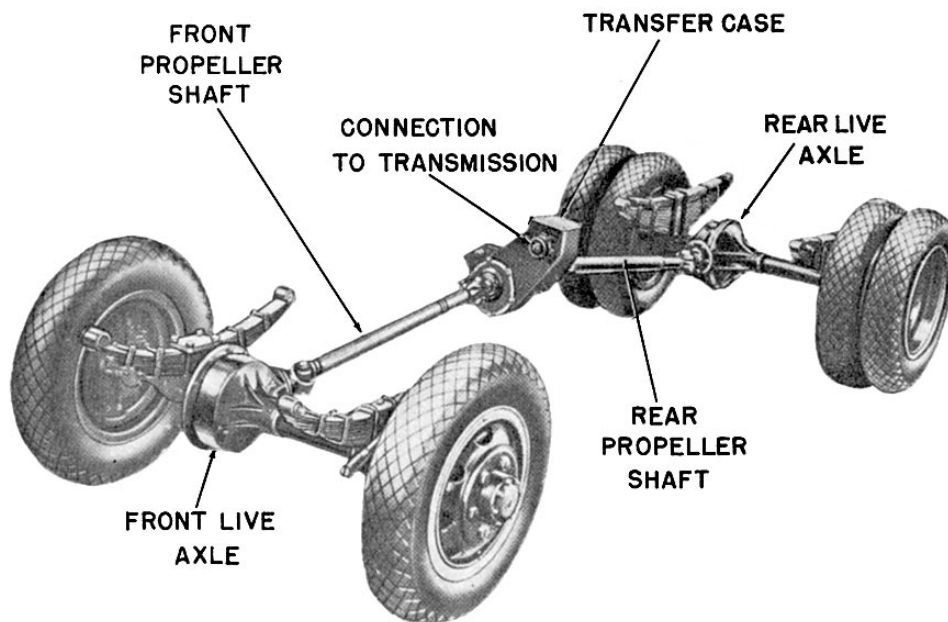
TRANSFER CASES

Transfer cases are put in the power trains of vehicles driven by all wheels. Their purpose is to provide the necessary offsets for additional propeller shaft connections to drive the wheels.

Transfer cases in heavier vehicles have two speed positions and a declutching device for disconnecting the front driving wheels. Two speed transfer cases, such as the one shown in figure 13-13, serve also as auxiliary transmissions.
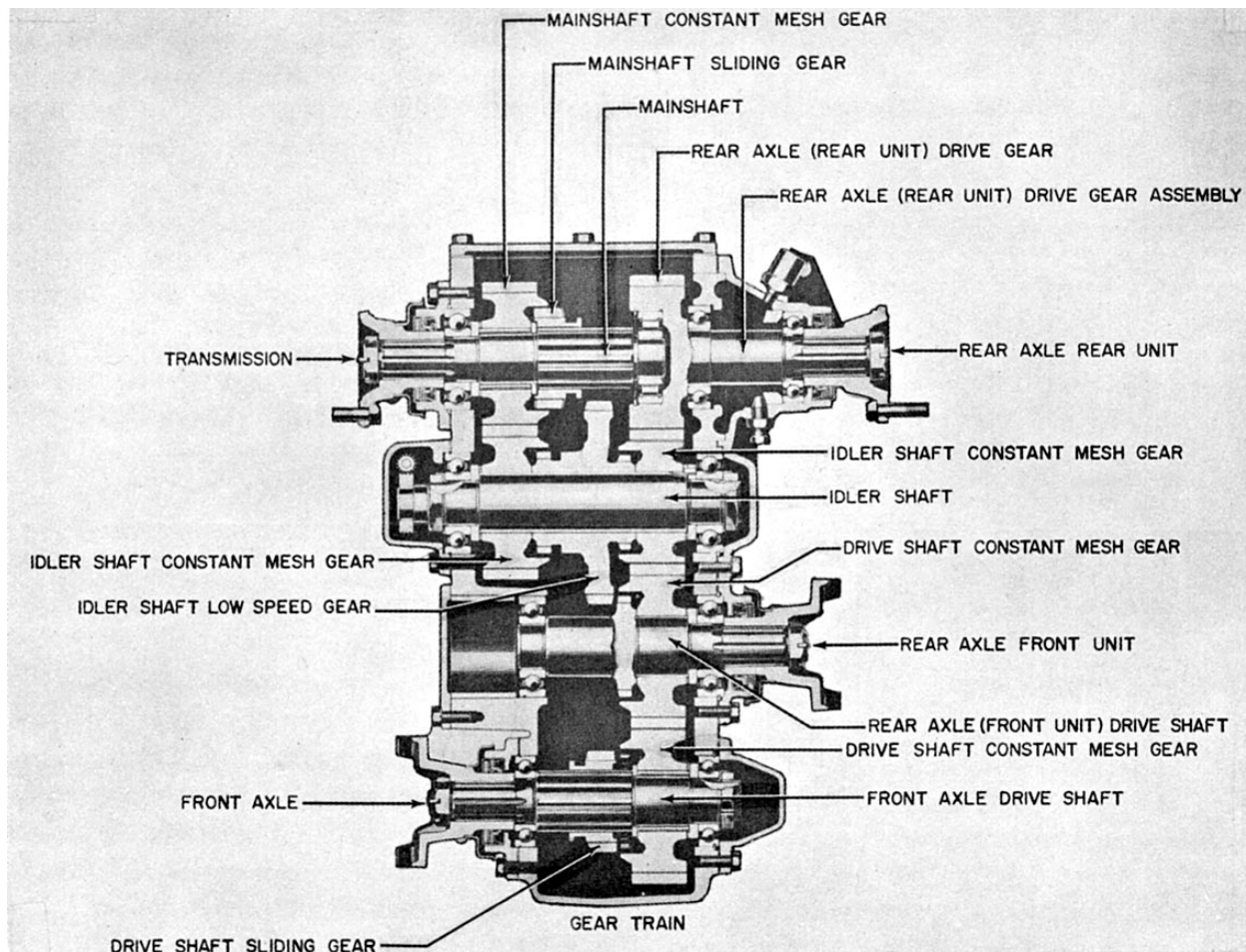
Some transfer cases are complicated. When they have speed-changing gears, declutching devices, and attachments for three or more propeller shafts, they are even larger than the main transmission. A cross section
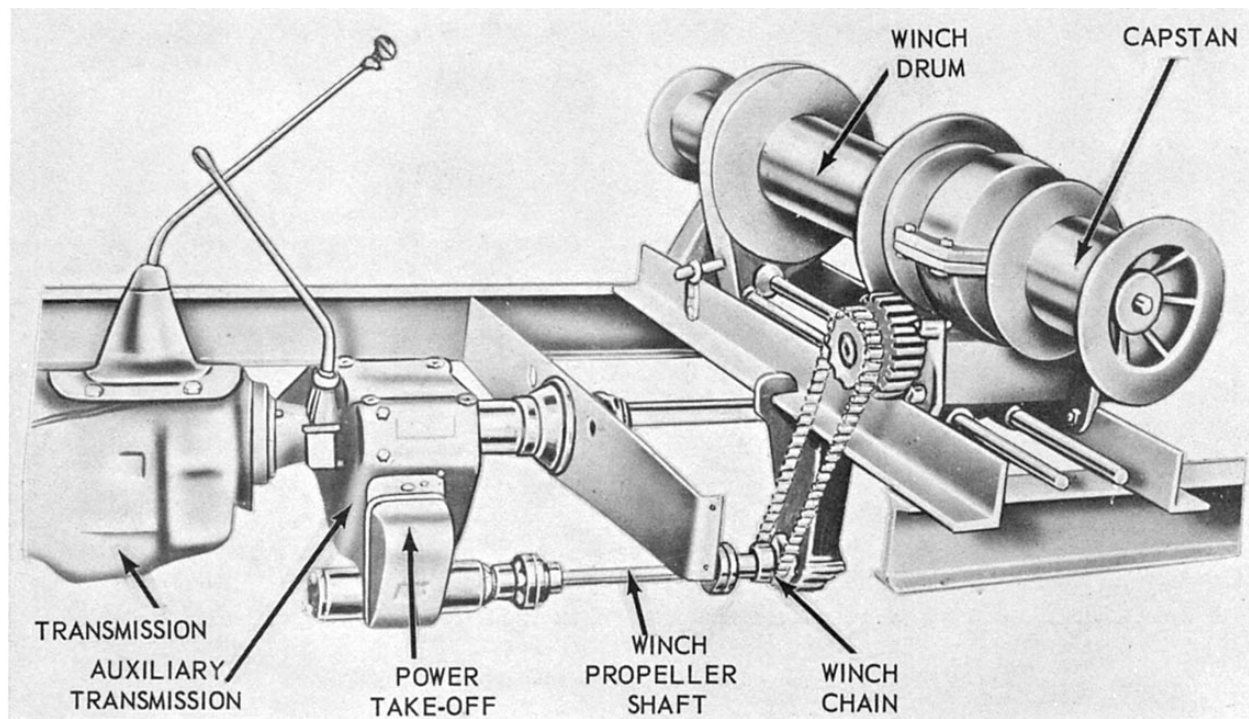
Figure 13-12.—Auxiliary transmission power takeoff driving winch.

Figure 13-13.—Transfer case installed in a four-wheel drive truck.

Figure 13-14.-Cross section of a two-speed transfer case.

of a common type of two-speed transfer case is shown in figure 13-14. Compare it with the actual installation in figure 13-13.

This same type of transfer case is used for a six-wheel drive vehicle. The additional propeller shaft connects the drive shaft of the transfer case to the rearmost axle assembly. It is connected to the transfer case through the transmission brake drum.

Some transfer cases contain an overrunning sprag unit (or units) on the front output shaft. (A sprag unit is a form of overrunning clutch; power can be transmitted through it in one direction but not in the other.)

On these units the transfer is designed to drive the front axle slightly slower than the rear axle. During normal operation, when both front and rear wheels turn at the same speed, only the rear wheels should lose traction and begin to slip. They tend to turn faster than the front wheels. As slipping occurs, the sprag unit automatically

engages so that the front wheels also drive the vehicle. The sprag unit simply provides an automatic means of engaging the front wheels in drive whenever additional tractive effort is required. There are two types of sprag-unit-equipped transfers, a single-sprag unit transfer and a double-sprag unit transfer. Essentially, both types work in the same manner.

POWER TAKEOFFS

Power takeoffs are attachments in the power train for power to drive auxiliary accessories. They are attached to the transmission, auxiliary transmission, or transfer case. A common type of power takeoff is the single-gear, single-speed type shown in figure 13-15. The unit bolts to an opening provided in the side of the transmission case as shown in figure 13-12. The sliding gear of the power takeoff will then mesh with the transmission countershaft gear. The operator can move a shifter shaft control lever to slide the gear in and out
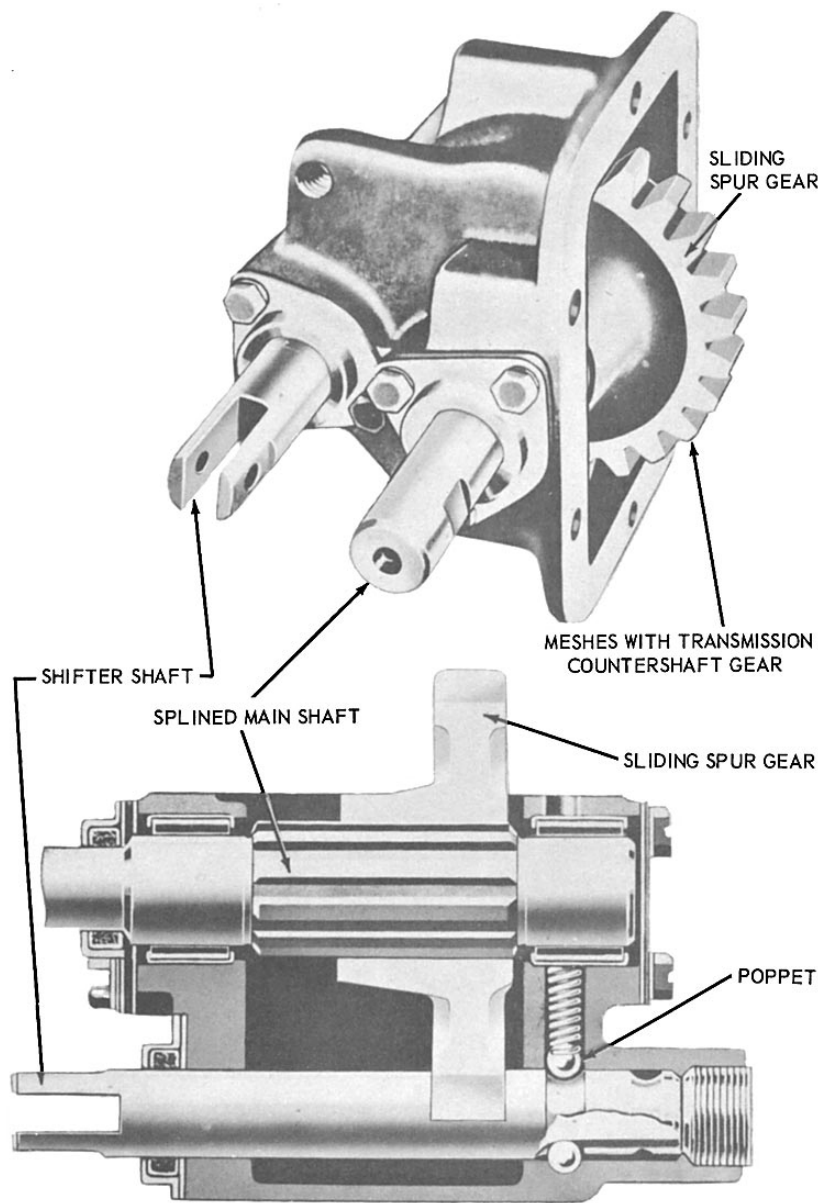
Figure 13-15.-Single-speed, single-gear, power takeoff.

of mesh with the countershaft gear. The spring-loaded ball holds the shifter shaft in position.

On some vehicles you will find power take-off units with gear arrangements that will give two speeds forward and one in reverse. Several forward speeds and a reverse gear arrangement are usually provided in power take-off units that operate winches and hoists. Their operation is about the same as that in the single-speed units.

PROPELLER SHAFT ASSEMBLIES

The propeller shaft assembly consists of a propeller shaft, a slip joint, and one or more universal joints. This assembly provides a flexible connection through which power is transmitted from the transmission to the live axle.

The propeller shaft may be solid or tubular. A solid shaft is stronger than a hollow or tubular shaft of the same diameter, but a hollow shaft is stronger than a solid shaft of the same weight. Solid shafts are used inside a shaft housing that encloses the entire propeller shaft assembly. These are called torque tube drives.

A slip joint is put at one end of the propeller shaft to take care of end play. The driving axle, attached to the springs, is free to move up and down, while the transmission is attached to the frame and cannot move. Any
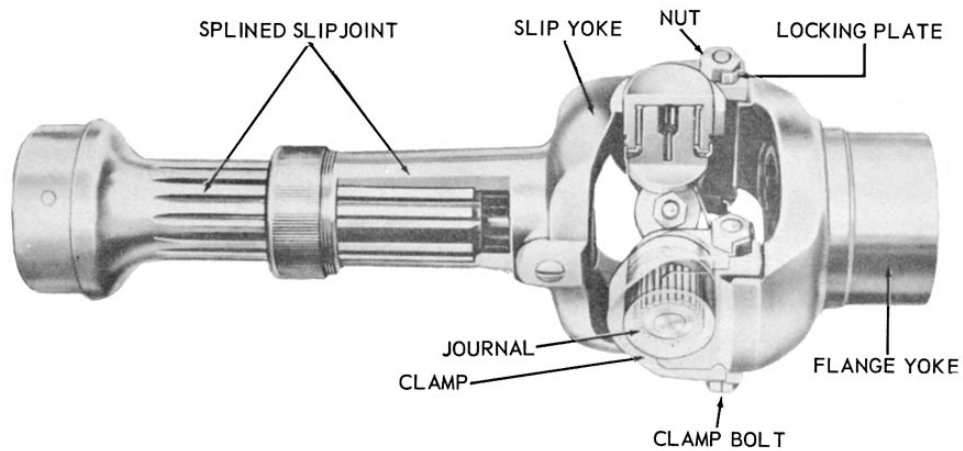
Figure 13-16.—Slip joint and common type of universal Joint.
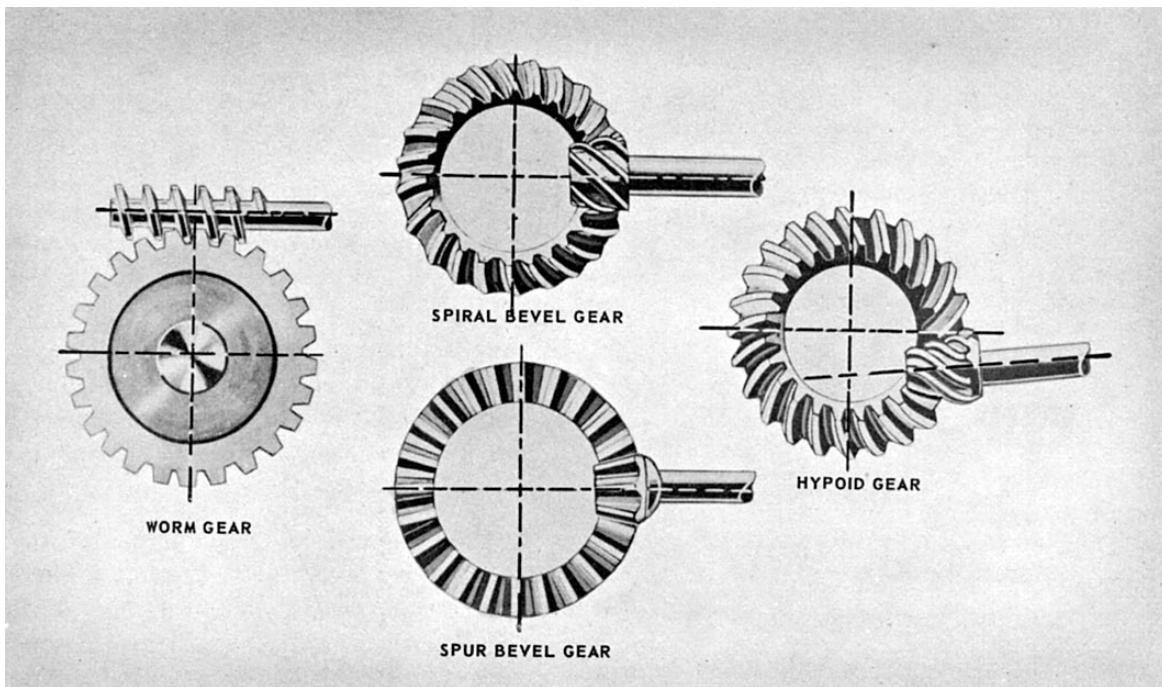
Figure 13-17.—Gears used in final drives.

upward or downward movement of the axle, as the springs flex, shortens or lengthens the distance between the axle assembly and the transmission. This changing distance is compensated for by a slip joint placed at one end of the propeller shaft.

The usual type of slip joint consists of a splined stub shaft, welded to the propeller shaft, that fits into a splined sleeve in the universal joint. A slip joint and universal joint are shown in figure 13-16.

Universal joints are double-hinged with the pins of the hinges set at right angles. They are made in many different designs, but they all work on the same principle. (See chapter 11.)

FINAL DRIVES

A final drive is that part of the power train that transmits the power delivered through the propeller shaft to the drive wheels or sprockets. Because it is encased in the rear axle housing, the final drive is usually referred to as a part of the rear axle assembly. It consists of two gears called the ring gear and pinion. These may

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be spur, spiral, hypoid beveled, or worm gears, as illustrated in figure 13-17.

The function of the final drive is to change by 90 degrees the direction of the power transmitted through the propeller shaft to the driving axles. It also provides a fixed reduction between the speed of the propeller shaft and the axle shafts and wheels. In passenger cars this reduction varies from about 3 to 1 to 5 to 1. In trucks, it can vary from 5 to 1 to as much as 11 to 1.

The gear ratio of a final drive having bevel gears is found by dividing the number of teeth on the drive gear by the number of teeth on the pinion. In a worm gear final drive, you find the gear ratio by dividing the number of teeth on the gear by the number of threads on the worm.

Most final drives are of the gear type. Hypoid gears (fig. 13-17) are used in passenger cars and light trucks to give more body clearance. They permit the bevel drive pinion to be put below the center of the bevel drive gear, thereby lowering the propeller shaft. Worm gears allow a large speed reduction and are used extensively in larger trucks. Spiral bevel gears are similar to hypoid gears. They are used in both passenger cars and trucks to replace spur gears that are considered too noisy.

DIFFERENTIALS

Chapter 11 described the construction and principle of operation of the gear differential. We will briefly review some of the high points of that chapter here and describe some of the more common types of gear differentials applied in automobiles and trucks.

The purpose of the differential is easy to understand when you compare a vehicle to a company of sailors marching in mass formation. When the company makes a turn, the sailors in the inside file must take short steps, almost marking time, while those in the outside file must take long steps and walk a greater distance to make the turn. When a motor vehicle turns a comer, the wheels outside of the turn must rotate faster and travel a greater distance than the wheels on the inside. That causes no difficulty for front wheels of the usual passenger car because each wheel rotates independently on opposite ends of a dead axle. However, to drive the rear wheel at different speeds, the differential is needed. It connects the individual axle shaft for each wheel to the bevel drive gear. Therefore, each shaft can turn at a different speed and still be driven as a single unit. Refer to the illustration in figure 13-18 as you study the following discussion on differential operation.
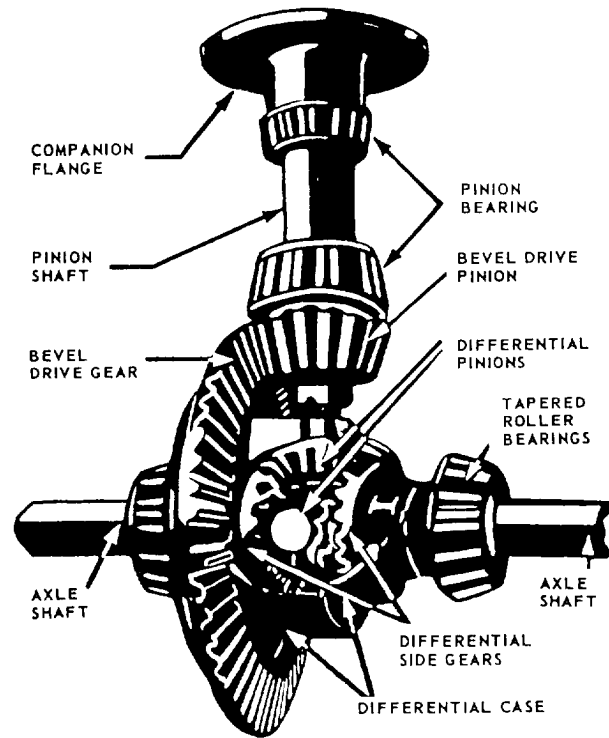

Figure 13-18.-Differential with part of case cut away.

The differential described in chapter 11 had two inputs and a single output. The differential used in the automobile has a single input and two outputs. Its input is introduced from the propeller shaft and its outputs goes to the rear axles and wheels.

The bevel drive pinion, connected to the pinion shaft, drives the bevel drive gear and the differential case to which it is attached. Therefore, the entire, differential case always rotates with the bevel drive gear whenever the pinion shaft is transmitting rotary motion. Within the case, the differential pinions (refereed to as spider gears in chapter 11) are free to rotate on individual shafts called trunnions. These trunnions are attached to the walls of the differential case. Whenever the case is turning, the differential pinions must revolve-one about the other-in the same plane as the bevel drive gear.

The differential pinions mesh with the side gears, as did the spider and side gears in the differential described in chapter 11. The axle shafts are splined to the differential side gears and keyed to the wheels. Power is transmitted to the axle shafts through the differential pinions and the side gears. When resistance is equal on each rear wheel, the differential pinions, side gears, and axle shafts all rotate as one unit with the bevel drive gear. In this case, there is no relative motion between the

pinions and the side gears in the differential case. That is, the pinions do not turn on the trunnions, and their teeth will not move over the teeth of the side gears.

When the vehicle turns a comer, one wheel must turn faster than the other. The side gear driving the outside wheel will run faster than the side gear connected to the axle shaft of the inside wheel. To compensate for this difference in speed and to remain in mesh with the two side gears, the differential pinions must then turn on the trunnions. The average speed of the two side gears, axle shafts, or wheels is always equal to the speed of the bevel drive gear.

Some trucks are equipped with a differential lock to prevent one wheel from spinning. This lock is a simple dog clutch, controlled manually or automatically, that locks one axle shaft to the differential case and bevel drive gear. This device forms a rigid connection between the two axle shafts and makes both wheels rotate at the same speed. Drivers seldom use it, however, because they often forget to disengage the lock after using it.

Several automotive devices are available that do almost the same thing as the differential lock. One that is used extensively today is the high-traction differential. It consists of a set of differential pinions and side gears that have fewer teeth and a different tooth form from the conventional gears. Figure 13-19 shows a comparison between these and standard gears.

The high-traction differential pinions and side gears depend on a variable radius from the center of the differential pinion to the point where it comes in contact with the side gear teeth, which is, in effect, a variable lever arm. While there is relative motion between the pinions and side gears, the torque is unevenly divided between the two driving shafts and wheels; whereas, with the usual differential, the torque is evenly divided always. With the high-traction differential, the torque becomes greater on one wheel and lesson the other as the pinions move around, until both wheels start to rotate at the same speed. When that occurs, the relative motion between the pinion and side gears stops and the torque on each wheel is again equal. This device helps to start the vehicle or keep it rolling when one wheel encounters a slippery spot and loses traction while the other wheel is on a firm spot and has traction. It will not work however, when one wheel loses traction completely. In this respect, it is inferior to the differential lock.

With the no-spin differential (fig. 13-20), one wheel cannot spin because of loss of tractive effort and thereby deprive the other wheel of driving effort. For example, one wheel is on ice and the other wheel is on dry pavement. The wheel on ice is assumed to have no traction. However, the wheel on dry pavement will pull to the limit of its tractional resistance at the pavement. The wheel on ice cannot spin because wheel speed is

CONVENTIONAL DIFFERENTIAL
PINION AND SIDE GEARS

HIGH TRACTION DIFFERENTIAL
PINION AND SIDE GEARS
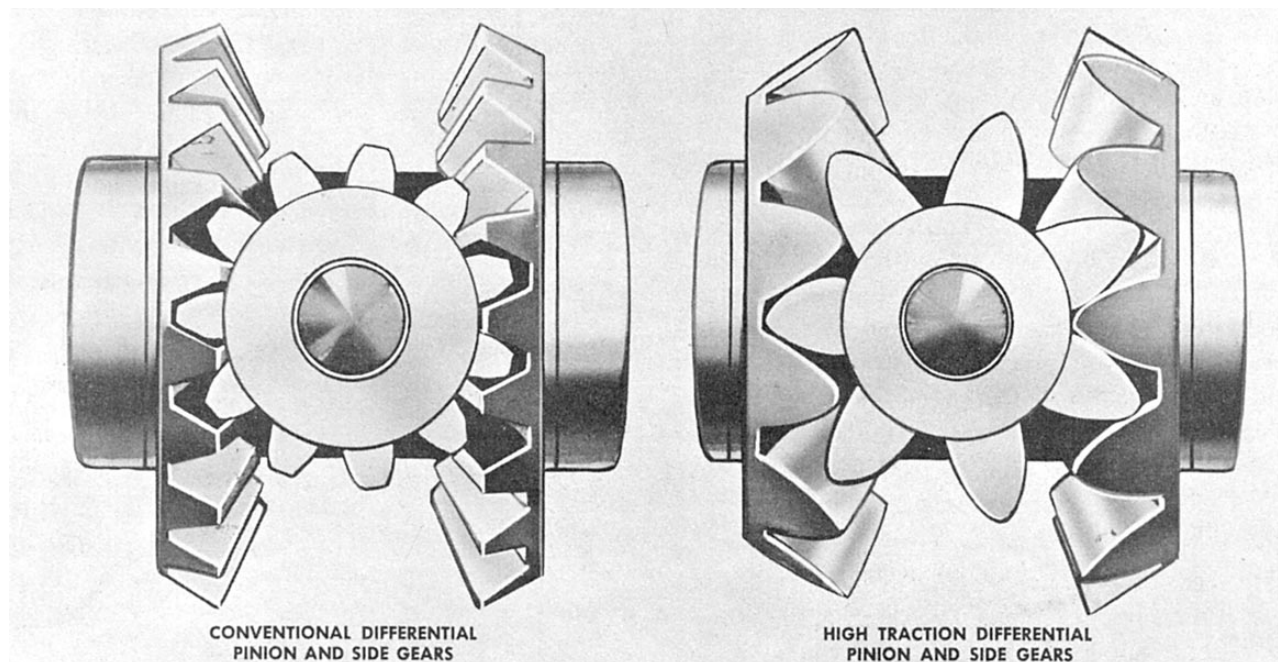
Figure 13-19.-Comparison of high-traction differential gears and standard differential gears.
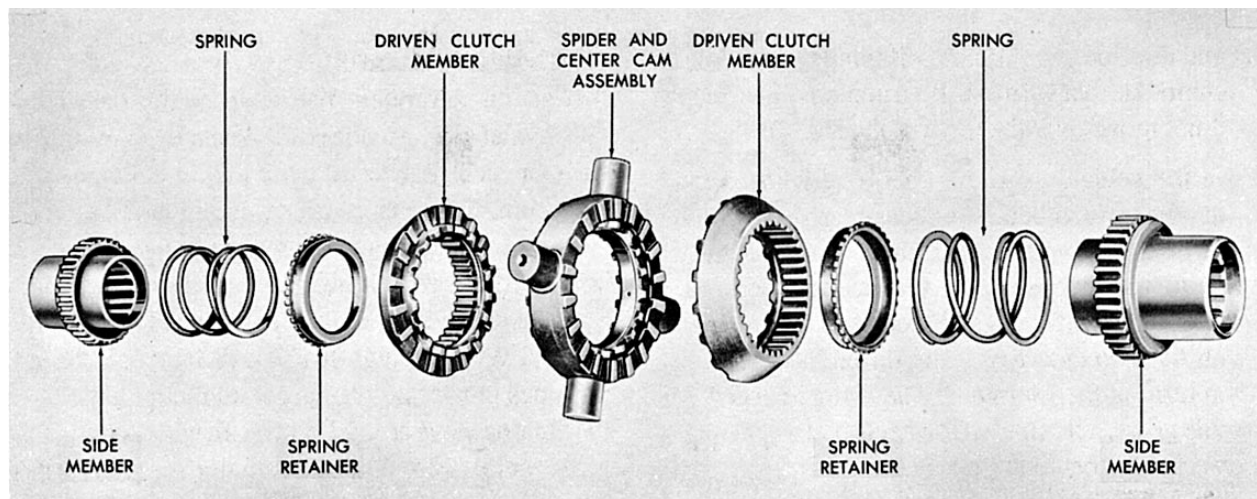
Figure 13-20.—No spin differential—exploded view.

governed by the speed of the wheel applying tractive effort.

The no-spin differential does not contain pinion gears and side gears as does the conventional differential. Instead, it consists basically of a spider attached to the differential drive ring gear through four trunnions. It also has two driven clutch members with side teeth that are indexed by spring pressure with side teeth in the spider. Two side members are splined to the wheel axles and, in turn, are splined into the driven clutch members.

AXLES

A live axle is one that supports part of the weight of a vehicle and drives the wheels connected to it. A dead axle is one that carries part of the weight of a vehicle but does not drive the wheels. The wheels rotate on the ends of the dead axle.

Usually, the front axle of a passenger car is a dead axle and the rear axle is a live axle. In four-wheel drive vehicles, both front and rear axles are live axles; in six-wheel drive vehicles, all three axles are live axles. The third axle, part of a bogie drive, is joined to the rearmost axle by a trunnion axle. The trunnion axle attaches rigidly to the frame. Its purpose is to help distribute the load on the rear of the vehicle to the two live axles that it connects.

Four types of live axles are used in automotive and construction equipment. They are: plain, semifloating, three-quarter floating, and full floating.

The plain live, or nonfloating, rear axle, is seldom used in equipment today. The axle shafts

in this assembly are called nonfloating because they are supported directly in bearings located in the center and ends of the axle housing. In addition to turning the wheels, these shafts carry the entire load of the vehicle on their outer ends. Plain axles also support the weight of the differential case.

The semifloating axle (fig. 13-21) used on most passenger cars and light trucks has its differential case independently supported. The differential carrier relieves the axle shafts from the weight of the differential assembly and the stresses caused by its operation. For this reason the inner ends of the axle shafts are said to be floating. The wheels are keyed to outer ends of axle shafts and the outer bearings are between the shafts and the housing. The axle shafts therefore must take the stresses caused by turning, skidding, or wobbling of the wheels. The axle shaft is a semifloating live axle that can be removed after the wheel has been pulled off.
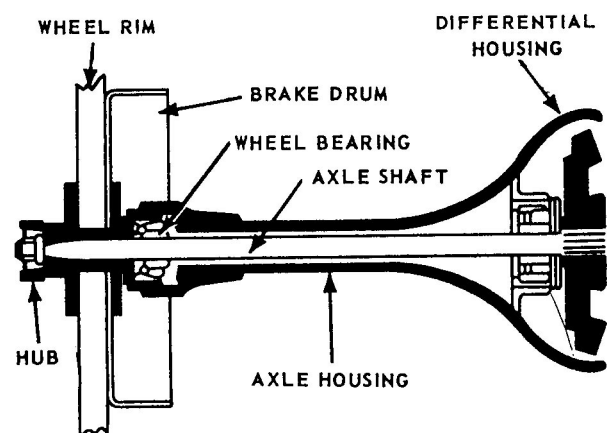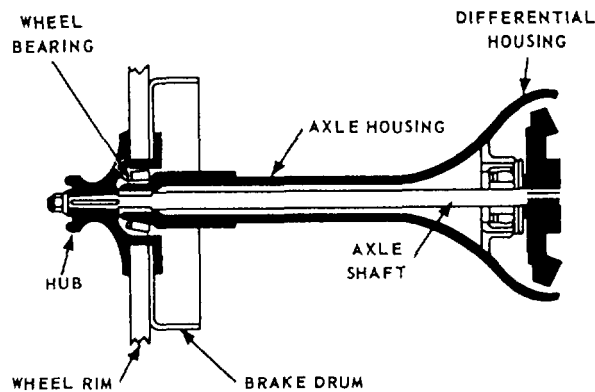

Figure 13-21.—Semifloating rear axle.

Figure 13-22.-Three-quarter floating rear axle.

Figure 13-23.-Full floating rear axle.

The axle shafts in a three-quarter floating axle (fig. 13-22) may be removed with the wheels, keyed to the tapered outer ends of the shafts. The inner ends of the shaft are carried as in a semifloating axle. The axle housing, instead of the shafts, carries the weight of the vehicle because the wheels are supported by bearings on the outer ends of the housing. However, axle shafts must take the stresses caused by the turning, skidding, and wobbling of the wheels. Three-quarter floating axles are used in some trucks, but in very few passenger cars. Most heavy trucks have a full floating axle (fig. 13-23). These axle shafts may be removed and replaced without removing the wheels or disturbing the differential. Each wheel is carried on the end of the axle tube on two ball bearings or roller bearings, and the axle shafts are not rigidly connected to the wheels. The wheels are driven through a clutch arrangement or flange on the ends of the axle shaft that is bolted to the outside of the wheel hub. The bolted connection between the axle and wheel does not make this assembly a true full floating axle, but nevertheless, it is called a floating axle. A true full floating axle transmits only turning effort, or torque.
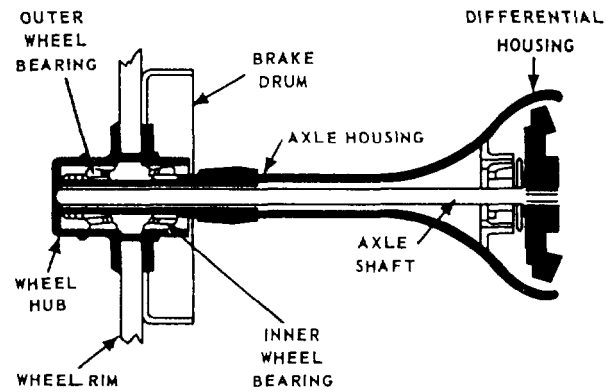
SUMMARY

Chapter 13 explained how power developed by the engine is transmitted to perform the work required of it. It discussed the following mechanisms of the power train:

The clutch is incorporated in the powertrain to provide a means of disconnecting the power of the engine from the driving wheels and accessory equipment.

The transmission transfers engine power from the clutch shaft to the propeller shaft and allows the operator to control the power and speed of the vehicle by selecting various gear ratios.

Transfer cases provide the necessary offsets for additional propeller shaft connections to drive the wheels.

Propeller shaft assemblies provide a flexible connection through which power is transmitted from the transmission to the axle.

Axles are used to support part of the weight of a vehicle; they also drive the wheels connected to them.